

Light Emitting Display, Display Panel, and Driving Method th r of

CROSS REFERENCE TO RELATED APPLICATION

5 This application claims priority to and the benefit of Korea Patent Application No. 2003-20433 filed on April 1, 2003 in the Korean Intellectual Property Office, the content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

10 **(a) Field of the Invention**

The present invention relates to a light emitting display, a display panel, and a driving method thereof. More specifically, the present invention relates to an organic electroluminescent (EL) display.

(b) Description of the Related Art

15 In general, an organic EL display electrically excites a phosphorous organic compound to emit light, and it voltage- or current-drives NxM organic emitting cells to display images. As shown in FIG. 1, an organic emitting cell includes an anode of indium tin oxide (ITO), an organic thin film, and a cathode layer metal. The organic thin film has a multi-layer structure including an emitting layer (EML), an electron transport layer (ETL), and a hole transport 20 layer (HTL) for maintaining balance between electrons and holes and improving emitting efficiencies, and it further includes an electron injecting layer (EIL) and a hole injecting layer (HIL).

Methods for driving the organic emitting cells include the passive matrix

method, and the active matrix method using thin film transistors (TFTs) or metal oxide semiconductor field effect transistors (MOSFETs). The passive matrix method forms cathodes and anodes to cross with each other, and selectively drives lines. The active matrix method connects a TFT and a capacitor with each ITO pixel electrode to thereby maintain a predetermined voltage according to capacitance. The active matrix method is classified as a voltage programming method or a current programming method according to signal forms supplied for maintaining a voltage at a capacitor.

Referring to FIGs. 2 and 3, conventional organic EL displays of the voltage programming and current programming methods will be described.

FIG. 2 shows a conventional voltage programming type pixel circuit for driving an organic EL element, representing one of NxM pixels. Referring to FIG. 2, transistor M1 is coupled to an organic EL element (referred to as an OLED hereinafter) to thus supply current for light emission. The current of transistor M1 is controlled by a data voltage applied through switching transistor M2. In this instance, capacitor C1 for maintaining the applied voltage for a predetermined period is coupled between a source and a gate of the transistor M1. Scan line S_n is coupled to a gate of transistor M2, and data line D_m is coupled to a source thereof.

As to an operation of the above-configured pixel, when transistor M2 is turned on according to a select signal applied to the gate of switching transistor M2, a data voltage from data line D_m is applied to the gate of transistor M1. Accordingly, current I_{OLED} flows to transistor M2 in correspondence to a voltage V_{GS} charged between the gate and the source by capacitor C1, and the OLED

emits light in correspondence to current I_{OLED} .

In this instance, the current that flows to the OLED is given in Equation 1.

Equation 1

$$I_{OLED} = \frac{\beta}{2}(V_{GS} - V_{TH})^2 = \frac{\beta}{2}(V_{DD} - V_{DATA} - |V_{TH}|)^2$$

where I_{OLED} is the current flowing to the OLED, V_{GS} is a voltage between the source and the gate of transistor M1, V_{TH} is a threshold voltage at transistor M1, and β is a constant.

As given in Equation 1, the current corresponding to the applied data voltage is supplied to the OLED, and the OLED gives light in correspondence to the supplied current, according to the pixel circuit of FIG. 2. In this instance, the applied data voltage has multi-stage values within a predetermined range so as to represent gray.

However, the conventional pixel circuit following the voltage programming method has a problem in that it is difficult to obtain high gray because of deviation of a threshold voltage V_{TH} of a TFT and deviations of electron mobility caused by non-uniformity of an assembly process. For example, in the case of driving a TFT of a pixel with 3 volts(3V), voltages are to be supplied to the gate of the TFT for each interval of 12mV (=3V/256) so as to represent 8-bit (256) grays, and if the threshold voltage of the TFT caused by the non-uniformity of the assembly process deviates, it is difficult to represent high gray. Also, since the value β in Equation 1 changes because of the deviations of the electron mobility, it becomes even more difficult to represent

the high gray.

On assuming that the current source for supplying the current to the pixel circuit is uniform over the whole panel, the pixel circuit of the current programming method can achieve uniform display features even though a driving transistor in each pixel has non-uniform voltage-current characteristics.

FIG. 3 shows a pixel circuit of a conventional current programming method for driving the OLED, representing one of NxM pixels. Referring to FIG. 3, transistor M1 is coupled to the OLED to supply the current for light emission, and the current of transistor M1 is controlled by the data current applied through transistor M2.

First, when transistors M2 and M3 are turned on because of the select signal from scan line S_n , transistor M1 becomes diode-connected, and the voltage matched with data current I_{DATA} from data line D_m is stored in capacitor C1. Next, the select signal from scan line S_n becomes high-level to turn on transistor M4. Then, the power is supplied from power supply voltage VDD, and the current matched with the voltage stored in capacitor C1 flows to the OLED to emit light. In this instance, the current flowing to the OLED is as follows.

Equation 2

$$I_{OLED} = \frac{\beta}{2}(V_{GS} - V_{TH})^2 = I_{DATA}$$

where V_{GS} is a voltage between the source and the gate of the transistor M1, V_{TH} is a threshold voltage at transistor M1, and β is a constant.

As given in Equation 2, since current I_{OLED} flowing to the OLED is the same as data current I_{DATA} in the conventional current pixel circuit, uniform

characteristics can be obtained when the programming current source is set to be uniform over the whole panel. However, since current I_{OLED} flowing to the OLED is a fine current, control over the pixel circuit by fine current I_{DATA} problematically requires much time to charge the data line. For example,
5 assuming that the load capacitance of the data line is 30pF, it requires several milliseconds of time to charge the load of the data line with the data current of several tens to hundreds of nA. This causes a problem that the charging time is not sufficient in consideration of the line time of several tens of microseconds.

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SUMMARY OF THE INVENTION

In accordance with the present invention to a light emitting display is provided for compensating for the threshold voltage of transistors or for electron mobility, and sufficiently charging the data line.

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In one aspect of the present invention, a light emitting display is provided on which are formed a plurality of data lines for transmitting data current that displays video signals, a plurality of scan lines for transmitting a select signal, and a plurality of pixel circuits formed at a plurality of pixels defined by the data lines and the scan lines. The pixel circuit includes: a light emitting element for emitting light corresponding to the applied current; a first transistor, having first and second main electrodes and a control electrode, for supplying a driving current for the light emitting element; a first switch for diode-connecting the first transistor in response to a first control signal; a second switch for transmitting a data signal from the data line in response to the select

signal from the scan line; a first storage element for storing a first voltage corresponding to the data current from the second switch in response to a second control signal; a second storage element for storing a second voltage corresponding to a threshold voltage of the first transistor in response to a disable level of the second control signal; and a third switch for transmitting the driving current from the first transistor to the light emitting element in response to a third control signal, wherein the second voltage is applied to the second storage element after the first voltage is applied to the first storage element, and a third voltage stored in the first storage element is applied to the first transistor by coupling of the first and second storage elements to output the driving current. The pixel circuit further includes a fourth switch that is turned on in response to the second control signal and has a first end coupled to a control electrode of the first transistor, and the fourth switch is turned on to form the first storage element, and the fourth switch is turned off to form the second storage element. The second storage element is formed by a first capacitor coupled between a control electrode and a first main electrode of the first transistor. The first storage element is formed by parallel coupling of first and second capacitors, the second capacitor being coupled between the first main electrode of the first transistor and a second end of the fourth switch. The first storage element is formed by a first capacitor coupled between a second end of the fourth switch and a first main electrode of the first transistor. The second storage element is formed by serial coupling of first and second capacitors, the second capacitor being coupled between the second end of the fourth switch and the control electrode of the first transistor. The first control signal is formed

by the first select signal and a second select signal from a next scan line having an enable interval after the first select signal. The first switch includes a second transistor for diode-connecting the first transistor in response to the first select signal, and a third transistor for diode-connecting the first transistor in response 5 to the second select signal. The second control signal is formed by the first select signal and the third control signal. The pixel circuit further includes a fifth switch coupled in parallel to the fourth switch. The fourth and fifth switches are respectively turned on in response to the first select signal and the third control signal.

10 In another aspect of the present invention, a method is provided for driving a light emitting display having a pixel circuit including a switch for transmitting a data current from a data line in response to a select signal from a scan line, a transistor including first and second main electrodes and a control electrode for outputting the driving current in response to the data current, and 15 a light emitting element for emitting light corresponding to the driving current from the transistor. A first voltage is stored corresponding to a data current from the switch in a first storage element formed between the control electrode and the first main electrode of the transistor. A second voltage corresponding to a threshold voltage of the transistor is applied to a second storage element formed between the control electrode and the first main electrode of the transistor. The first and second storage elements are coupled to establish the 20 voltage between the control electrode and the first main electrode of the transistor as a third voltage. The driving current is transmitted from the transistor to the light emitting display. The driving current from the transistor is

determined corresponding to the third voltage.

In still another aspect of the present invention, a display panel of a light emitting display is provided, on which are formed a plurality of data lines for transmitting the data current that displays video signals, a plurality of scan lines for transmitting a select signal, and a plurality of pixel circuits formed at a plurality of pixels defined by the data lines and the scan lines. The pixel circuit includes: a light emitting element for emitting light corresponding to the applied current; a first transistor for outputting the current for driving the light emitting element; a first switch for transmitting the data current from the data line to the first transistor in response to a first select signal from the scan line; a second switch diode-connecting the first transistor in response to a first control signal; a third switch for operating in response to a second control signal; a fourth switch for transmitting the driving current from the transistor to the light emitting element in response to a third control signal; a first storage element formed between a control electrode and a first main electrode of the first transistor when the third switch is turned on; and a second storage element formed between the control electrode and the first main electrode of the first transistor when the third switch is turned off. The display panel operates in the order of: a first interval for applying a first voltage corresponding to the data current to the first storage element, a second interval for applying a second voltage corresponding to a threshold voltage of the first transistor to the second storage element, and a third interval for generating the driving current by a third voltage stored in the first storage element by the first and second voltages.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a concept diagram of an OLED.

FIG. 2 shows an equivalent circuit of a conventional pixel circuit following the voltage programming method.

5 FIG. 3 shows an equivalent circuit of a conventional pixel circuit following the current programming method.

FIG. 4 shows a brief plane diagram of an organic EL display according to an embodiment of the present invention.

10 FIGs. 5, 7, and 9 respectively show an equivalent circuit of a pixel circuit according to first through third embodiments of the present invention; and

FIGs. 6 and 8 respectively show a driving waveform for driving the pixel circuit of FIGs. 5 and 7.

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DETAILED DESCRIPTION

An organic EL display, a corresponding pixel circuit, and a driving method thereof will be described in detail with reference to drawings.

First, referring to FIG. 4, the organic EL display will be described. FIG. 4 shows a brief ground plan of the OLED.

20 As shown, the organic EL display includes an organic EL display panel 10, scan driver 20, and data driver 30.

Organic EL display panel 10 includes a plurality of data lines D₁ through D_m in the row direction, a plurality of scan lines S₁ through S_n and E₁ through E_n,

and a plurality of pixel circuits 11. Data lines D_1 through D_m transmit data signals that represent video signals to the pixel circuit 11, and scan lines S_1 through S_n transmit select signals to pixel circuit 11. Pixel circuit 11 is formed at a pixel region defined by two adjacent data lines D_1 through D_m and two adjacent scan lines S_1 through S_n . Also, scan lines E_1 through E_n transmit emit signals for controlling emission of pixel circuits 11.

Scan driver 20 sequentially applies respective select signals and emit signals to the scan lines S_1 through S_n and E_1 through E_n . The data driver 30 applies the data current that represents video signals to the data lines D_1 through D_m .

Scan driver 20 and/or data driver 30 can be coupled to display panel 10, or can be installed, in a chip format, in a tape carrier package (TCP) coupled to display panel 10. The same can be attached to display panel 10, and installed, in a chip format, on a flexible printed circuit (FPC) or a film coupled to display panel 10, which is referred to as a chip on flexible board, or chip on film (CoF) method. Differing from this, scan driver 20 and/or data driver 30 can be installed on the glass substrate of the display panel, and further, the same can be substituted for the driving circuit formed in the same layers of the scan lines, the data lines, and TFTs on the glass substrate, or directly installed on the glass substrate, which is referred to as a chip on glass (CoG) method.

Referring to FIGs. 5 and 6, pixel circuit 11 of the organic EL display according to the first embodiment of the present invention will now be described. FIG. 5 shows an equivalent circuit diagram of the pixel circuit according to the first embodiment, and FIG. 6 shows a driving waveform diagram for driving the

pixel circuit of FIG. 5. In this instance, for ease of description, FIG. 5 shows a pixel circuit coupled to an m-th data line D_m and an n-th scan line S_n .

As shown in FIG. 5, pixel circuit 11 includes an OLED, PMOS transistors M1 through M7, and capacitors C1 and C2. The transistor is preferably a thin film transistor having a gate electrode, a drain electrode, and a source electrode formed on the glass substrate as a control electrode and two main electrodes.

Transistor M1 has a source coupled to power supply voltage VDD, and a gate coupled to transistor M5, and transistor M3 is coupled between the gate and a drain of transistor M1. Transistor M1 outputs current I_{OLED} corresponding to a voltage V_{GS} at the gate and the source thereof. Transistor M3 diode-connects transistor M1 in response to a select signal SE_{n+1} from the scan line S_{n+1} coupled to a pixel circuit provided on the (n+1)th row. The transistor M7 is coupled between the data line D_m and the gate of the transistor M1, and diode-connects the transistor M1 in response to a select signal SE_n from the scan line S_n . In this instance, the transistor M7 can be coupled between the gate and the drain of transistor M1 in the like manner of transistor M3.

Capacitor C1 is coupled between power supply voltage VDD and the gate of transistor M1, and capacitor C2 is coupled between power supply voltage VDD and a first end of transistor M5. Capacitors C1 and C2 operate as storage elements for storing the voltage between the gate and the source of the transistor. A second end of transistor M5 is coupled to the gate of transistor M1, and transistor M6 is coupled in parallel to transistor M5. Transistor M5 couples capacitors C1 and C2 in parallel in response to select signal SE_n from scan line

S_n , and transistor M6 couples capacitors C1 and C2 in parallel in response to an emit signal EM_n from scan line E_n .

Transistor M2 transmits data current I_{DATA} from data line D_m to transistor M1 in response to a select signal SE_n from scan line S_n . Transistor M4 coupled between the drain of transistor M1 and the OLED, transmits current I_{OLED} of transistor M1 to the OLED in response to an emit signal EM_n of scan line E_n . The OLED is coupled between transistor M4 and the reference voltage, and emits light corresponding to applied current I_{OLED} .

Referring to FIG. 6, an operation of the pixel circuit according to the first embodiment of the present invention will now be described in detail.

As shown, in interval T1, transistor M5 is turned on because of low-level select signal SE_n , and capacitors C1 and C2 are coupled in parallel between the gate and the source of transistor M1. Transistors M2 and M7 are turned on to diode-connect transistor M1, and transistor M2 is turned on to have data current I_{DATA} from data line D_m flow to transistor M1. Since data current I_{DATA} flows to transistor M1, data current I_{DATA} can be expressed as Equation 3, and the gate-source voltage V_{GS} (T1) in interval T1 is given as Equation 4 derived from Equation 3.

Equation 3

$$I_{DATA} = \frac{\beta}{2} (|V_{GS}(T1)| - |V_{TH}|)^2$$

Equation 4

$$|V_{GS}(T1)| = \sqrt{\frac{2I_{DATA}}{\beta}} + |V_{TH}|$$

where β is a constant, and V_{TH} is a threshold voltage of transistor M1.

Therefore, capacitors C1 and C2 store the voltage $V_{GS}(T1)$ corresponding to data current I_{DATA} . Transistor M4 is turned off by a high-level emit signal EM_m to intercept the current to the OLED.

5 Next, in interval T2, transistors M2, M5, and M7 are turned off in response to a high-level select signal SE_n , and transistor M3 is turned on in response to a low-level select signal SE_{n+1} . Transistor M6 is currently turned off by high-level emit signal EM_m . Capacitor C2 is floated by turned-off transistors M5 and M6 while capacitor C2 stores the voltage expressed in Equation 4.

10 Since data current I_{DATA} is intercepted by turned-off transistor M2, and transistor M1 is diode-connected by turned-on transistor M3, capacitor C1 stores the threshold voltage V_{TH} of transistor M1.

In interval T3, transistor M3 is turned off in response to high-level select signal SE_{n+1} , and transistors M4 and M6 are turned off in response to the low-level emit signal. When transistor M6 is turned on, capacitors C1 and C2 are coupled in parallel, and the gate-source voltage $V_{GS}(T3)$ at transistor M1 in interval T3 becomes Equation 5 because of coupling of capacitors C1 and C2.

Equation 5

$$|V_{GS}(T3)| = |V_{TH}| + \frac{C_2}{C_1 + C_2} (|V_{GS}(T1)| - |V_{TH}|)$$

20 where C1 and C2 are respectively capacitance of capacitors C1 and C2.

Therefore, current I_{OLED} flowing to transistor M1 becomes as Equation 6, and current I_{OLED} is supplied to the OLED because of turned-on transistor M4, to thereby emit light. That is, in interval T3, the voltage is provided and the

OLED emits light because of coupling of capacitors C1 and C2.

Equation 6

$$I_{OLED} = \frac{\beta}{2} \left\{ \frac{C_2}{C_1 + C_2} (|V_{GS}(T1)| - |V_{TH}|) \right\}^2 = \left(\frac{C_2}{C_1 + C_2} \right)^2 I_{DATA}$$

As expressed in Equation 6, since current I_{OLED} supplied to the OLED is determined with no relation to the threshold voltage V_{TH} of transistor M1 or the mobility, the deviation of the threshold voltage or the deviation of the mobility can be corrected. Also, current I_{OLED} supplied to the OLED is $C1/(C1+C2)$ squared times smaller than data current I_{DATA} . For example, if C1 is M times greater than C2 ($C1=M\times C2$), the fine current flowing to the OLED can be controlled by data current I_{DATA} which is $(M+1)^2$ times greater than current I_{OLED} , thereby enabling representation of high gray. Further, since large data current I_{DATA} is supplied to data lines D_1 through D_m , charging time for the data lines can be sufficiently obtained. Also, since transistors M1 through M7 are of the same type, it is easy to form the TFTs on the glass substrate of display panel

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In the first embodiment, PMOS transistors are used to realize transistors M1 through M7, and NMOS transistors can also be used to realize the same. In the case of realizing transistors M1 through M5 with NMOS transistors, the source of transistor M1 is coupled to not power supply voltage VDD but the reference voltage, the cathode of the OLED is coupled to transistor M4, and the anode thereof is coupled to power supply voltage VDD in the pixel circuit of FIG. 5. Select signals SE_n and SE_{n+1} have an inverted format of the waveform of FIG. 6. Since a detailed description of applying the NMOS

transistors to transistors M1 through M5 can be easily known by the description of the first embodiment, no further detailed description will be provided. Also, transistors M1 through M7 can be realized by combination of PMOS and NMOS transistors, or other switches performing similar functions.

5 Seven transistors M1 through M7 are used to realize the pixel circuit in the first embodiment, and in addition, the number of transistors can be reduced by adding a scan line for transmitting a control signal, which will now be described with reference to FIGs. 7 through 12.

10 FIG. 7 shows an equivalent circuit diagram of the pixel circuit according to a second embodiment of the present invention, and FIG. 8 shows a driving waveform diagram for driving the pixel circuit of FIG. 7.

15 As shown in FIG. 7, transistors M6 and M7 are removed from and scan lines X_n and Y_n are added to the pixel circuit of FIG. 5, in the pixel circuit according to the second embodiment. The gate of transistor M3 is coupled to scan line X_n, and diode-connects transistor M1 in response to control signal CS_{1n} from scan line X_n. The gate of transistor M5 is coupled to scan line Y_n and couples capacitors C1 and C2 in parallel in response to control signal CS_{2n} from scan line Y_n.

20 Referring to FIG. 8, transistors M3 and M5 are turned on by low-level control signals CS_{1n} and CS_{2n} to diode-connect transistor M1 and couple capacitors C1 and C2 in parallel. Transistor M2 is turned on by low-level select signal SE_n to have data current I_{DATA} from data line D_m flow to transistor M1. Therefore, the gate-source voltage V_{GS}(T1) is given as Equation 4 in a like manner of interval T1 according to the first embodiment, and the voltage

$V_{GS}(T1)$ is stored in capacitors C1 and C2.

Next, in interval T2, transistor M5 is turned off by high-level control signal $CS2_n$ to float capacitor C2 while it is charged. Transistor M2 is turned off by high-level select signal SE_n to intercept data current I_{DATA} . Therefore, 5 capacitor C1 stores threshold voltage V_{TH} of transistor M1 in the same manner of interval T2 according to the first embodiment.

In interval T3, transistor M3 is turned off by high-level control signal $CS1_n$, and transistor M5 is turned off in response to low-level control signal $CS2_n$. When transistor M5 is turned on, capacitors C1 and C2 are coupled in 10 parallel, and the gate-source voltage $V_{GS}(T3)$ of transistor M1 in interval T3 is given as Equation 5 in the same manner of interval T3 according to the first embodiment.

As described, the pixel circuit according to the second embodiment 15 operates in the same manner of the first embodiment, but the number of transistors is reduced compared to that of the first embodiment.

In the second embodiment, the number of transistors is reduced by two, and the number of scan lines is increased by two. Further, it is also possible to reduce the number of transistors by one and increase the number of scan lines by one.

For example, transistor M6 is removed from the pixel circuit of FIG. 5, and the gate of transistor M5 is coupled to scan line Y_n for transmitting control signal $CS2_n$ as shown in FIG. 7. Transistor M5 is turned on in intervals T1 and 20 T3 with low-level control signal $CS2_n$ to thereby couple capacitors C1 and C2 in parallel, which has the same operation as that of the first embodiment.

Also, transistor M7 is removed from the pixel circuit of FIG. 5, and the gate of transistor M3 is coupled to scan line X_n for transmitting control signal CS_{1n} as shown in FIG. 7. Transistor M3 is turned on in intervals T1 and T2 with low-level control signal CS_{1n} to thereby diode-connect transistor M1, which has the same operation as that of the first embodiment.

In the first and second embodiments, capacitors C1 and C2 are coupled in parallel to power supply voltage VDD, and differing from this, capacitors C1 and C2 can be coupled in series to power supply voltage VDD, which will now be described referring to FIG. 9.

FIG. 9 shows an equivalent circuit diagram of the pixel circuit according to a third embodiment of the present invention.

As shown, the pixel circuit has the same structure as that of the second embodiment except the coupling states of capacitors C1 and C2, and transistor M5. In detail, capacitors C1 and C2 are coupled in series between power supply voltage VDD and transistor M3, and transistor M5 is coupled between the common node of capacitors C1 and C2 and the gate of transistor M1.

The pixel circuit according to the third embodiment is driven with the same driving waveform as that of the second embodiment, which will now be described referring to FIGs. 8 and 9.

In interval T1, transistor M3 is turned on by low-level control signal CS_{1n} to diode-connect transistor M1. Transistor M5 is turned on by low-level control signal CS_{1n} to make the voltage at capacitor C2 0V. Transistor M2 responds to low-level select signal SE_n to have data current I_{DATA} from the data line flow to transistor M1. The gate-source voltage $V_{GS}(T1)$ of transistor M1 is

given as Equations 3 and 4 by data current I_{DATA} . Also, transistor M4 is turned off by high-level emit signal EM_n to intercept the current flow to the OLED.

In interval T2, control signal $CS2_n$ becomes high level to turn off transistor M5, and select SE_n becomes high level to turn off transistor M2.

Since transistor M1 is diode-connected by turned-on transistor M3, the threshold voltage V_{TH} at transistor M1 is applied to capacitors C1 and C2 coupled in series. Hence, the voltage V_{C1} at capacitor C1 charging the voltage $V_{GS}(T1)$ shown in FIG. 4 becomes as shown in Equation 7 because of coupling of capacitors C1 and C2.

Equation 7

$$V_{C1} = |V_{TH}| + \frac{C_1}{C_1 + C_2} (|V_{GS}(T1)| - |V_{TH}|)$$

Next, in interval T3, transistor M3 is turned off in response to high-level control signal $CS1_n$, and transistors M5 and M4 are turned on by low-level control signal $CS2_n$ and emit signal EM_n . When transistor M3 is turned off, and transistor M5 is turned on, the voltage V_{C1} at capacitor C1 becomes the gate-source voltage $V_{GS}(T3)$ of transistor M1. Therefore, current I_{OLED} flowing to transistor M1 becomes as shown in Equation 8, and current I_{OLED} is supplied to the OLED according to transistor M4 thereby emitting light.

Equation 8

$$I_{OLED} = \frac{\beta}{2} \left\{ \frac{C_1}{C_1 + C_2} (|V_{GS}(T1)| - |V_{TH}|) \right\}^2 = \left(\frac{C_1}{C_1 + C_2} \right)^2 I_{DATA}$$

In the like manner of the first embodiment, current I_{OLED} supplied to the OLED is determined with no relation to the threshold voltage V_{TH} of transistor

M1 or the mobility in the third embodiment. Also, since the fine current flowing to the OLED using data current I_{DATA} that is $(C1+C2)/C1$ squared times current I_{OLED} can be controlled, high gray can be represented. By supplying large data current I_{DATA} to data lines D_1 through D_M , sufficient charging time of the data lines can be obtained.

In the third embodiment, PMOS transistors are used to realize transistors M1 through M5, and further the pixel circuit can be realized by NMOS transistors, combination of the PMOS and NMOS transistors, or other switches performing similar functions.

According to the present invention, since the current flowing to the OLED can be controlled by a large data current, sufficient data lines can be sufficiently charged for a single line time. Also, the threshold voltage of the transistor or deviation of mobility is corrected according to the current flowing to the OLED, and light emitting display with high resolution and wide screen can be realized.

While this invention has been described in connection with what is presently considered to be practical embodiments it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.